

Study of the Digestive Rate of Coarse Cellulose of Giant Pandas

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Abstract Comparative study and analysis were undertaken by the authors on the digestive rate of animal ration's coarse cellulose in *bamboo powder + concentrates* and *bamboo + concentrates* by man-fed Giant pandas at Fuzhou Giant Panda Research Center in the attempt to find out effective ways to raise the digestive and absorptive rates of coarse cellulose and to prevent giant panda from intestinal obstruction. The results demonstrate: 1. The difference in digestive rate of coarse cellulose between *bamboo powder + concentrates* and *bamboo + concentrates* is extremely significant ($t=15.73>t_{0.01}(4,3)=3.57$). 2. The digestive rate of coarse cellulose in bamboo powder made of different bamboo species is not notably different ($F=2.05 < F_{0.05}(2,8)=4.46$). 3. In the experiment group, there exists no notable difference in digestive rate of coarse cellulose of bamboo powder among individuals ($P>0.01$). The experiment shows that if giant panda is fed with mechanically ground bamboo combined with concentrates of balanced nutrients, the digestive rate of coarse cellulose in the rations can be favorably increased, thus the effective utilization of bamboo as a line of the animal's feed and the raising feeding returns can be made more effective. The effects of bamboo powder on Giant pandas digestive organs and digestive physiology, digestive rate of coarse cellulose of different bamboo species, the difference in digestive functions among individual Giant Panda needs further studies.

Key words: Giant panda, Coarse cellulose, Digestive rate, Bamboo powder, Combined feed, Regular feed

Introduction

Bamboo is main food of the giant panda in wild and man-fed giant panda was fed much bamboo besides concentrates that were made of grain powder to keep its feeding habits in wild, but the digestive rate of coarse cellulose is very low, in both wild and man-fed pandas. We can find that the bamboo was almost not digested from the feces that contained much bamboo sticks. Chen Yuchun etc. (1993) reported that the digestive rate in bamboo coarse cellulose is about 25% only. The authors designed this experiment to find a way to improve the

digestive rate of bamboo coarse cellulose. The experiment is introduced as follows.

Materials and Methods

This experiment was conducted at Fuzhou Giant Panda Research Center from 7 May to 19 May, 1996, during which 7th-10th is pre-experiment period and 11th-19th is experiment period. The 5 adult giant pandas in the Research Center as tested animals were divided into two groups: the experiment group and the control group (see Table 1).

Table 1. The division of experiment group and control group of tested giant pandas

Group	Name	Sex	Age (year)	Weight (kg)
Experiment group	Taotao, Basi, Rong	Male, Female, Female	24, 16, 10	93.9, 115.5, 82.5
Control group	Qingqing, Zhengzheng	Female, Male	20, 14	106.0, 102.5

Giant pandas in experiment group and control group were given different feed, *bamboo powder + concentrates* and *bamboo + concentrates* respectively. Concentrates in both two kinds of feeds contained same composition, corn powder 32%, wheat bran 22%, soybean

12%, rich 15%, millet 7% and flour 12%. The concentrates were steamed in which bamboo powder was mixed. The whole bamboo was given to the control group directly. Clean water was supplied for free drink.

Table 2. The digestive rate of rational coarse cellulose of giant panda

Name	Item	11th	12th	13th	16th	14th	15th	19th	17th	18th	$\bar{x} \pm \sigma$
Qingqing	Take-in (g)	330.66	222.93	128.09	269.16	308.45	257.92	223.10	189.10	205.10	237.17 ± 58.61
	Discharge (g)	268.20	181.90	101.50	216.14	246.70	206.00	178.50	155.10	164.60	190.96 ± 47.32
	Digestive rate (%)	18.89	18.40	20.76	19.70	20.02	20.13	19.99	17.98	19.75	19.51 ± 0.85
Zhenzhen	Take-in (g)	141.73	115.32	169.10	214.09	203.56	205.13	140.19	181.22	171.22	167.28 ± 37.25
	Discharge (g)	122.70	98.60	143.60	178.90	171.40	170.30	120.30	149.90	142.90	138.73 ± 24.48
	Digestive rate (%)	13.43	14.50	15.08	16.51	15.80	16.98	14.19	17.28	16.54	15.59 ± 1.28
Basi	Take-in (g)	227.79	215.78	185.95	195.80	190.99	169.29	164.30	177.43	168.79	188.46 ± 20.60
	Discharge (g)	166.29	159.31	130.87	140.31	136.77	123.07	118.05	144.73	126.11	138.39 ± 15.34
	Digestive rate (%)	26.80	26.17	29.62	28.34	29.39	27.30	28.15	27.70	25.29	26.57 ± 1.34
Rongrong	Take-in	216.66	167.56	167.03	149.20	124.84	125.80	133.94	161.34	167.90	157.14 ± 26.89
	Discharge (g)	162.43	118.95	119.84	107.00	90.92	88.55	95.60	114.50	115.80	112.57 ± 20.96
	Digestive rate (%)	25.05	29.01	28.25	28.28	27.17	29.60	28.63	29.03	28.28	28.14 ± 1.27
Taotao	Take-in	224.93	248.50	243.83	230.83	229.00	193.50	168.50	202.90	144.30	209.59 ± 33.34
	Discharge (g)	170.20	184.00	183.10	183.10	171.10	143.10	121.60	147.30	105.84	156.58 ± 27.13
	Digestive rate (%)	24.33	25.96	24.13	24.91	25.28	26.05	27.83	27.40	26.65	25.83 ± 1.22

Empty stomach weight was measured before experiment. The experiment began after 3 days of pre-experiment period, in which giant pandas were supplied with *Sinarundinaria nitida* on 11th, 12th, 13th and 16th, *Neosinocalmus affinis* on 14th, 15th, 19th and *Bambusa multiplex* 17th, 18th. The whole feces method was employed in the tests. Every 2 hours, feces were collected and weighed, and watery HCl was added to the feces samples to fix free NH₃. At the same time, the amount of concentrates, bamboo powder and bamboo fed every day was also weighed and recorded. Feed samples and excrement samples were dried in thermostatic container at 60-70 °C for 6 h and then kept in bottles for further analysis.

Normal chemical analysis methods were adopted to analyze the content of coarse cellulose in the concentrates, bamboo, bamboo powder and feces samples. The daily quantity of coarse cellulose of bamboo taken in and discharged of each tested giant panda can be calculated by weighing the quantity of concentrated feed, bamboo powder, bamboo taken in and feces discharge per day. The difference between the digestive rate of coarse cellulose of bamboo powder and bamboo were analyzed by statistical comparison.

Results and Statistical Analysis

Results of t-test of the difference of coarse cellulose, digestive rate between bamboo and bamboo powder

The quantity of coarse cellulose taken in and discharge by tested giant pandas are listed in table 2. \bar{x}_1 stands for the mean digestive rate of coarse cellulose in control group, and \bar{x}_2 for that in experiment group. It is indi-

cated that the coarse cellulose digestive rate in the experiment group that were fed with bamboo powder + concentrates is extremely significantly higher than that in the control group that were fed with bamboo + concentrates ($P > 0.01$).

The comparison of the difference between different bamboo species taken in and different individual

Five giant pandas were fed with 3 species of bamboo (*Sinarundinaria nitida*, *Neosinocalmus affinis* *Bambusa multiplex*) during the 9 days experiment period. After the digestive experiment, the differences of coarse cellulose digestive rate between the 3 species of bamboo taken in were tested by single variance analysis. The test data are shown in Table 3, by regarding the different giant pandas as factor A, and different bamboo species as factor B.

Among different bamboo species, $F_A=2.05 < F_{0.05}$ (2,8)=4.46. The results indicates that there is no significant difference of the coarse cellulose in digestive rate between different bamboo species ($P > 0.05$). Among different individuals, $F_B=124.03 > F_{0.01}$ (4,8)=7.04, that means there exist significant difference of the coarse cellulose in digestive rate between different individuals ($P < 0.01$).

LSR method was adopted in the multiple comparison of the digestive rate of the coarse cellulose in ration among different giant pandas. Table 4 shows the detail comparison.

Table 4 shows that there is an extremely significant difference of coarse cellulose digestive rate between experiment group and control group ($P < 0.01$). For the 3 giant pandas in the experiment group, there exists no significant difference between any two ones ($P > 0.05$),

while for the two giant pandas in the control group, there exists an extremely significant difference ($P < 0.01$).

The difference of ration coarse cellulose digestive rate effected by two factors, the different bamboo species

and different giant pandas, was tested. Table 5 shows the detail comparison by regarding the different giant pandas as factor A, and different bamboo species as factor B.

Table 3. Variance analysis of coarse cellulose digestive rate among individual and different bamboo species.

Giant panda	Qingqing	Zhenzhen	Taotao	Basi	Rongrong	$T_i = \sum x_i$	$\bar{x}_i = (1/4)T_i$
<i>Smardindaria nitida</i>	19.26	15.06	24.13	27.69	27.44	113.58	22.72
<i>N. affinis</i>	20.05	14.77	26.27	27.96	28.48	117.53	23.51
<i>B. multiplex</i>	18.90	16.72	27.09	28.48	27.53	118.92	23.78
T_i	58.21	46.75	77.49	84.13	83.45	T=350.03	
\bar{x}_i	19.40	15.58	25.83	28.04	27.28		

Table 4. Multiple comparison of coarse cellulose digestive rate among different tested giant pandas

Name	Mean value	$\bar{x}_1 - x_i$	$\bar{x}_2 - x_i$	$\bar{x}_3 - x_i$	$\bar{x}_4 - x_i$
Basi	28.04	0			
Rongrong	27.82	0.16	0		
Taotao	25.83	2.21	1.39	0	
Qingqing	19.40	8.64	8.42	6.63	0
Zhenzhen	15.58	12.64	12.24	10.25	3.82

The results indicate that there exists an extremely significant difference of coarse cellulose digestive rate among individuals ($F_A = 183.80 > F_{0.01}(4, 30) = 4.02$); no significant difference among different bamboo species

($F_B = 0.53 < F_{0.05}(2, 30) = 3.32$); When factor A (individual) and factor B (bamboo species) are considered together, the difference of coarse cellulose digestive rate is significant ($F_{AB} = 2.43 > F_{0.05}(8, 30) = 2.27$).

Table 5. Difference analysis of coarse cellulose digestive rate affected by factors A and B

	Qingqing		Taotao		Zhenzhen		Basi		Rongrong		T_i	\bar{x}_i
<i>Smardindaria nitida</i>	18.89		24.33		13.43		27.00		25.03			
	18.40	77.75	25.96	99.33	14.50	59.44	26.17	111.13	29.01	110.57	458.72	22.91
	20.76		24.91		15.08		29.62		28.25			
<i>Bambusa multiplex</i>	19.70		24.13		16.43		28.34		28.28			
	20.02		25.28		15.80		29.39		27.17			
	20.13	60.14	26.05	79.13	14.15	46.93	27.30	84.84	29.60	85.40	353.63	23.58
<i>Neosinocalmus affinis</i>	19.99		27.83		16.98		28.15		28.63			
	17.98	37.73	27.40	54.05	17.28	33.82	24.68	49.97	29.03	55.06	230.63	
	19.75		26.65		16.54		25.29		26.02			
T_i	175.62		232.51		140.19		245.97		251.03		T=1042.53	
\bar{x}_i	19.51		25.84		15.57		27.33		27.89		$\bar{x} = 23.17$	

Discussion

The results of the tests of difference significance indicate that the digestive rate of ration coarse cellulose in experiment group that were fed with bamboo powder + concentrates is extremely higher ($P < 0.01$) than that in control group that were fed with bamboo + concentrates. That means that bamboo treated by certain grinding processes is benefit to enhance the digestive rate of coarse cellulose.

The structure of the digestive tracts of giant panda are still keeping the features of carnivores, such as short digestive tract, no cecum, short maintenance of food in digestive tract and lack of digestive enzymes, bacteria and microorganism that can digest coarse cellulose. After a long history of evolution, giant panda was forced to live mainly on bamboo, but such feed habits is limited by the structure and function of digestive organs. Thus, the digestive rate of bamboo, especially the coarse cellulose appears to be extremely low (Chen Yuchun, 1993).

While bamboo is processed into powder by grinder, the area of digestive juice action surface can be extended, so that the digestive rate of coarse cellulose is able to increase.

The difference significance tests indicate that different bamboo species have no significant effect on the digestive rate of the coarse cellulose in giant panda's ration. However, those bamboo species that exhibit good palatability and meet the addiction of giant pandas should be selected as the raw material of bamboo powder. Commonly, giant pandas like sweet bamboo, especially the nutritional, fresh and tender bamboo shoots and leaves.

In the experiment group that were fed with *bamboo powder + concentrates*, there appears no significant difference of the digestive rate of coarse cellulose among different individuals ($P > 0.05$); while in the control group that were fed with *bamboo + concentrates*, there appears significant difference ($P < 0.01$). A further study on the causes making such difference in control group and the difference of individual digestive function or some other factors, should be conducted in the future.

Some suggestions are supported by the investigation:

1. For increasing the digestive rate of coarse cellulose of bamboo, bamboo powder mixed within the concen-

trates should be adopted

2. There is no significant effect of bamboo species on the digestive rate of coarse cellulose

There are still some questions to be solved: the disadvantages of bamboo powder to the digestive organs and functions after fed with it for a long time; the long-time affection if such combined feed was applied in the raising of penned-in and wild giant pandas, etc..

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(Responsible Editor: Sun Yucqi)